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An assemblage of framings and tamings: multi-sited analysis of infrastructures as a methodology

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ABSTRACT
The *social life of methods* – the idea that research methods are an important topic of inquiry in and of themselves – has been receiving increasing interest in scholarship on the organisation of the economy and social life, including Science and Technology Studies (STS). In STS, especially ethnographic methods have been important for decades. This article develops an ethnographic methodology for the study of a very new case that challenges the assumptions underpinning many STS ethnographies. This case is the networked energy infrastructure, and we specifically focus on its risk management and markets. Drawing upon recent STS interest in multi-sited ethnography, the article's research design is termed the *multi-sited analysis of infrastructures* (MSAI), and it develops the concepts of *framing and taming* to focus on meaning formation as mundane sense-making and as technicalised reasoning on different sites. We demonstrate these concepts in a multi-sited ethnography of energy infrastructure and its risk management and market activities in public regulation, special control rooms (including energy trading), and households. The article rounds up by explaining how the application of our methodology contributes to the advancement of interests in multi-sited ethnography, relating our research to the previous work in the fields of STS, infrastructure studies, and their methods.

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Introduction

In Science and Technology Studies (STS), ethnographic methods such as fieldwork and participant observation have been central since the first generation of laboratory studies and the rise of the Sociology of Scientific Knowledge in the 1980s (Hess 2001, Hine 2007). STS scholars have made several advancements with ethnography, a methodology of data collection for observing how actors produce scientific and technological knowledge in normally restricted settings, usually in their own environments and contexts (Beaulieu 2010, Parmiggiani and Monteiro 2016). Doing ethnography aligns with the aims of the classic Sociology of Scientific Knowledge (see Hess 2001) – to study the production of scientific evidence and consistency subject to negotiations, local decision-making, and interpretation by expert actors. If we accept that social research methods have a 'social life' – that they are not mere techniques but open up certain social worlds and hence partly bring them about (Law and Ruppert 2013, Savage 2013) – then these STS assumptions should receive increasing scrutiny considering how they shape views about science and technology.

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In this article, we develop an ethnographic methodology for the study of a very new case that challenges the assumptions underpinning many STS ethnographies. This case is the networked electricity infrastructure, and we specifically focus on its risk management and markets in special control rooms, energy-using households, and public regulation models that govern energy distribution risks. Our contribution joins recent scholarly discussions that have produced new considerations of ethnography as an STS methodology. Inspired by what anthropologist George Marcus (1995) calls *multi-sited ethnography*, STS researchers have begun to expand their field studies – going further than one laboratory or other single sites of expert knowledge and instead conducting research on multiple field sites.

At a time when localities are transgressed by transnational discourses, techniques of governance, financial markets, and communication networks, multi-sitedness implies developing careful analyses of the very connectedness between distinct ethnographic field sites (Marcus 1995, Ong and Collier 2005, Rabinow *et al.* 2008, Collier 2011). As a methodological strategy, multi-sitedness means adding generality to specific findings from such distinct sites. This is very important even in fieldwork in 'small places,' such as one village, which can reveal multiple external interconnections and layers (Candea 2013). Multi-sited approaches bring together existing research knowledge, organisational contexts, and historical timeframes with ethnographic sensitivity to situated and local activities, hence considerably expanding local ethnographies (Pollock and Williams 2009, 2010, Hyysalo *et al.* 2018). Sociologist Christine Hine (2007) summarises multi-sited ethnography as a 'middle-range methodology' in STS: its research techniques are suitable for in-depth engagement with data from distinct sites, but also apt for reaching beyond their particularity and developing more generic concepts and theories from those premises.

This article advances concrete research suggestions, strategies, and recipes for multi-sited methodologies in an area where these perspectives are of clear relevance – namely energy infrastructures. From Thomas P. Hughes's (1983) Large Technological Systems and infrastructure studies (Edwards 2003, 2010), the urban geography of liberalised and privatised infrastructures (Graham and Marvin 2001), and Multi-Level Perspectives on sustainability transitions (Verbong and Geels 2007, Köhler *et al.* 2017), research in this field has established that infrastructural technologies like electricity, telecommunications, heating, and transportation integrate many parts of society and adjust to them (Jalas *et al.* 2016). The layers relevant to infrastructures range from international markets to legislations and regulations, supply companies, scientific research programmes, and practices of everyday infrastructure use (Van der Vleuten 2004, Mitchell 2008). For example, electricity networks enable professional lives, the experience of modernity, human needs, modern habits, and even state power through national electricity grids that make electricity available constantly and ubiquitously (Boyer 2015, Abram *et al.* 2019). Sustainable energy transition provides a timely example of these insights: studies show us that political cultures, economic trends, industry actors, technologies, institutions, rules, regulations, and many other parts of energy infrastructures have to change and reinforce one another for a successful transition to a more sustainable model of energy provision (Verbong and Geels 2007, Silvast *et al.* 2013).

In sum, recent research has recognised the multiplicity of energy transitions and their processual character and raised methodological questions about moving 'beyond the single case and the isolated research object' (Köhler *et al.* 2017, p. 46). However, multi-sited approaches are rarely addressed as advancements that could accomplish this goal (cf. Boyer 2015, Abram *et al.* 2019). Indeed, until a few years ago, energy policy research and social research on energy was, for the most part, single-sited: it was research from a particular standpoint, in one nation-state or subnational region, or concerning only a particular energy technology (see the overview in Sovacool 2014). There is a distinct sense that this area still prizes single-sited studies for their rigour, such as when assessing comparative case studies against single case studies and arguing that '(s)ingle case studies tend to be evidence-rich, allowing a range of relevant factors to be measured and assessed' (Sovacool *et al.* 2018, p. 30).

Related to this, STS and its associated fields have experienced an entirely 'localist turn' (Pollock *et al.* 2016, Hyysalo *et al.* 2018) – meaning an increasing amount of research that focuses on detailed organisational practices, assuming the local practices are unique to that particular organisation. Studies focusing on one site are adept at capturing the first-hand experiences of technology design and use. Furthermore, and significantly, the dependence of research and researchers on project funding has a structuring impact that may support these kinds of snapshot case studies rather than long-term multi-sited ethnographic work.

Overall, while STS theory anticipates that energy is a multi-sited socio-technical infrastructure, we contend that multi-sited methodologies have not reached their full potential in this area. Our article aims to provide a toolkit for addressing this issue. To attain its aim, the article carries out four tasks. Firstly, it explores and discusses concepts that explain the notion of an ethnographic site and the necessity for multi-sited research with a focus on infrastructure studies. In so doing, it draws upon established theories from STS and other related fields including sociology, anthropology, and philosophy.

Secondly, we operationalise these theories to a set of guiding questions and tools for empirical research. Our research design is termed the *multi-sited analysis of infrastructures* (MSAI) and develops two main conceptual tools to grasp different aspects of meaning-formation: the concept of *framing* focuses on mundane, rarely reflected upon forms of sense-making on different sites, while the concept of *taming* guides us to examine cognitive, rationalised, and technicalised forms of framing. Both concepts – and framing in particular – are also concepts in the social study of markets, and we connect them to that research tradition.

Thirdly, we demonstrate the use of these conceptual tools through a multi-sited ethnography of the electric power infrastructure and its risk management and market activities on three field sites: at the public regulatory scale, in special electricity control rooms, and in households.

Fourthly and lastly, the article concludes by explaining how the application of our methodology contributes to the advancement of STS interest in multi-sited ethnography. This part develops more discussion on the relation of our methods to the previous work in this field – especially to the emerging Biography of Artifacts and Practices (BOAP) approach (Pollock and Williams 2009, 2010, Hyysalo *et al.* 2018) and the tools of classic infrastructure studies including 'infrastructural inversion' (Bowker and Star 1999) and 'boundary objects' (Star and Griesemer 1989). As the complete infrastructure cannot be mapped exhaustively, we suggest that a multi-sited ethnography of it advances a middle-ground between in-depth engagement on distinct sites and more generic concepts and theories reaching beyond their particularity.

Conceptual positioning

The inherently complex nature of infrastructures yields myriad angles of approach, as is well known in STS (e.g. Star 1999, Edwards 2003, 2010, Van der Vleuten 2004, Karasti *et al.* 2016, Parmiggiani and Monteiro 2016). For example, Paul N. Edwards (2003) situates infrastructure into three 'levels': the level of individuals and small groups; the level of institutions, such as corporations and standard-setting bodies; and the level of political economies and governments. These divisions offer a heuristic for understanding the social organisation of infrastructure – the ways in which infrastructure exists at the same time in every household, large organisation, and regulatory body.

Observations of complex and interconnected technologies such as infrastructures demand these kinds of methodological guidelines to control the level of complexity in the analysis. Guidelines are necessary to appreciate the scale and level – or the 'granularity' – of the observation. We cannot keep an eye on a whole electricity infrastructure, for example, which simultaneously encompasses everything from local technical components and national transmission networks to international electricity markets. However, the methodological strategy of reducing the observation to one point only goes against the inherently complex nature of the infrastructure. Hence, we develop and introduce a rigorous methodology for examining infrastructures such as electricity networks that both reduces and gives leeway for the complexity of their composition in a controlled manner. We conceptualise the research design of what we term the *multi-sited analysis of infrastructures* (MSAI) to achieve this goal.

The use of a multi-sited approach to rethink the interrelations of space and place has been a topic in both the cultural sciences and STS (see Hine 2007), especially since Marcus's 1995 review of the emergent methodological trend in anthropology at that time – namely multi-sited ethnography (Marcus 1995, 1998). Globalised flows of information, cultural products, money, migration, and technoscience mean that societal and cultural phenomena cannot be isolated to a single location and observed by focusing on one site alone (Rapp 1999, Ong and Collier 2005, Collier 2011). Appadurai (1996) speaks of 'scapes' as spheres of life made up of or articulated by diverse globalised flows. Different, potentially global scapes – such as the financescape, which consists of flows of money – connect different locations and people (cf. Sassen 1991) or different sites, and produce different, increasingly global risks in so doing (Centeno and Cohen 2010, Centeno *et al.* 2015).

Among the recently developed multi-sited methodologies in STS, the Biography of Artifacts and Practices (BOAP) (Pollock and Williams 2009, 2010, Hyysalo *et al.* 2018) stresses very similar points. It starts from the importance of historical context and focuses on the relationships that it takes on from technology studies – between users, designers, and the various intermediaries in between them. One strategy in multi-sited ethnography is to follow the 'artefact' around while considering its appropriation by different technological actors over time. However, multi-sited ethnographies may also seek to follow people, metaphors, certain stories, plots, allegories, conflicts, or the lives of people (Marcus 1995) – or to follow the continuous formation of infrastructures across sites, as we will do here.

The vantage point of multi-sitedness opens up the inherent crosscutting characteristics of the phenomena under scrutiny. Starting from multiple sites leads to a methodological focus on connections and nexuses, and on processes of translations between sites. With these issues in view, we examine the composition of an infrastructure not as a single phenomenon or object but as a folded assemblage of diverse practices, both enacting the infrastructure and attuning to it. Hence, our MSAI methodology focuses on intermediations across sites on different scales. It guides us to look at both the multiplicity and the coherence of a diverse infrastructures such as electricity supply. It also guides inquiries into both the objects and their making. Infrastructure is constantly made, but at the same time, it is – as a resistant and lively socio-material assemblage – part of this making process. The infrastructure is enacted on multiple sites in specific multiple practices. However, these various practices of infrastructure enactment are simultaneously attuned to the infrastructure as a coherent and robust entity.

Methodology: framing and taming

We develop the tandem concepts of *framing* and *taming* as tools for our MSAI research design. These concepts help us to analyse different aspects of the construction of and attunement to infrastructures, and to keep our focus on the processual and frictional nature of the formation of infrastructures on different sites. *Framing*, a concept made famous by the sociologist Erving Goffman (1974), is the more general of the two, as it refers to all the mundane ways by which individuals understand and make sense of situations at hand. According to Goffman, these

> definitions of a situation are built up in accordance with principles of organisation which govern events – at least social ones – and our subjective involvement in them; frame is the word I use to refer to such of these basic elements as I am able to identify. (Goffman 1974, pp. 10–11)

Consequently, framings are the basic elements of meaning-formation that mediate the subjective and the objective. On the one hand, people use framings to understand what it is that is going on in a situation, but, on the other hand, the framings they use are neither completely arbitrary nor voluntaristic.

We utilise the concept of framing to focus on mundane and often unreflected upon processes of sense-making on different sites. Infrastructures are constantly made sense of in habitual, everyday routines. For example, the electricity network is particularly meaningful for making daily practices possible. This framing, which is constantly formed during the practice of everyday life, leaves the complexity of the infrastructure behind and the various possibilities electricity provides mostly blackboxed, so long as it functions adequately (Shove 2017).

In cultural economy and STS literature, framing is also used in a more particular sense, as a technical simplification: it is a reduction of complexity from a technical angle, for instance by making things commensurable with the market models of economics (Callon 1998). This happens, for example, when infrastructural concerns are addressed by the introduction of new markets, as two cultural economy scholars note: 'agents must be equipped to become calculative, and goods must be stabilised and framed in order to make exchange possible' (Pallesen and Jacobsen 2018, p. 2). For the past years, energy consumers have received attention as these kinds of 'calculative agents': they are expected to switch their power suppliers, closely follow energy prices, make rational decisions, and hence strengthen the power markets both nationally and transnationally (European Commission 2019). This has become pronounced in building the EU's internal market for electricity and 'smart' energy systems, which are expected to support active consumers that 'take their own decisions on how to produce, store, sell, or share their own energy'; using devices such as smart energy metres that allow consumers to be 'informed about their energy consumption and costs in real time' (European Commission 2019, p. 12, see Silvast *et al.* 2018).

Paying attention to these kinds of framings reveals two insights. The first is that framings may be *performative*: the active, material, social, and technical configuration of elements as being economic not only describes a market, but can also bring markets about, at least temporarily (e.g. McFall 2010, see Silvast 2017a for an overview). The second important point is that this effect is not linear and does not need to happen predictably. Framings are precarious achievements that can fail when the frames become fragile, incomplete, or contested, as has happened with the framing of renewable energies as economic commodities via market support mechanisms in several energy markets (Cointe 2015, Pallesen 2016).

These conceptualisations contain elements of the second part of our conceptual tandem, *taming*. The origins of the concept of taming can be traced back to Ian Hacking's historical-philosophical oeuvre. In Hacking's (1975, 1990) work, the erosion of determinism from the seventeenth century onwards ushered in techniques to control indeterminism. Chance had to be tamed, and Hacking's historical work stresses the advent of probabilistic statistical models and approximate laws in this regard. We adopt Hacking's idea of taming as an active process of complexity reduction by means of technologies and techniques or – to use another of Hacking's concept – styles of reasoning. Tamings are cognitive, rationalised, and technicalised forms of framing. In methodological terms, the concept of taming leads us to focus on active and conscious, organised, and technicalised processes that aim at taming the complexities at hand. In our research context, the active taming of complexities of infrastructures involves various material tools, such as software and communications devices; checklists and protocols; and styles of reasoning, such as cost–benefit calculations.

We merge Hacking's idea of the taming of chance with Goffman's mundane frames to calibrate the MSAI as a conceptual tool. Framing and taming are not mutually exclusive categories but analytical tools to highlight different aspects of ongoing infrastructure-making on different sites. Framings and tamings can, for example, alternate sequentially in the specialised electricity control rooms that we examine in this article. Experts frame the infrastructure – and, at the same time, their own work – routinely and mainly unreflectively as long as this framing is not challenged by anomalous occurrences. An alarm, for instance, leads to more cognitive taming work and the need to adjust existing framings actively. One can find similar cycles at work in households when routinely utilised infrastructures, such as electricity, cease functioning – the disruption of everyday life creates doubt about existing habitual framings and makes one form new habits as fast as possible (Silvast 2017b).[1]

An inherent critical potential also resides in the research design of the MSAI. The construction of and attunement to infrastructures is not necessarily a unitary and frictionless process without power relations. As we examine infrastructures consisting of diverse framings and tamings on different field sites, potential asymmetries surface between the sites vis-à-vis framings and tamings. Daily life is highly dependent on electricity, for example. As electricity users, we are not only connected to the electricity infrastructure in material ways, but also by the framings and tamings carried out outside the scope of our own framings. By using electricity, we are shaped as electricity customers, preferably rational, price-conscious ones. Electricity infrastructure conveys not only electricity, but also the technical taming work of electricity as money-mediated and cost-efficient.

To sum up, by utilising the MSAI equipped with the frame/tame tandem:

We, firstly, approach infrastructures from a multi-sited point of view. Multi-sited research design enables us to observe how infrastructures are enacted and attuned to on different field sites.

Secondly, we utilise the conceptual tandem of framing and taming to grasp both mundane and unreflected framings as well as cognitive-technical tamings in these enactments of and attunements to infrastructures on different sites.

Thirdly, we focus on the overlaps and connections as well as translations and frictions of different framings and tamings both on one field site as well as on and between different sites.

Fourthly, we target subtle power relations in these processes and address the performative aspect of the distribution of framings and tamings across sites.

In the following, we illustrate our research design in a multi-sited ethnography of the electric power infrastructure and its risk management and market activities.

Multiple sites in the electricity infrastructure

The empirical basis of this article consists of ethnographic fieldwork carried out by the first author in Finland between 2004 and 2008. We draw upon the semi-structured interviews with electricity experts and lay people in addition to participant observation and a selection of key policy documents in this area from the time. Twelve interviews and 20 hours of participant observation were conducted in two electricity control rooms of a Finnish city – one for coordinating the local electricity grid, the other for trading electricity on the Nordic common stock exchange.[2] In addition, nine householders were interviewed semi-structurally, and over 100 households returned a short survey.[3] More than 50 key policy documents were gathered during this fieldwork, out of which the article uses a selection that focuses on the public regulation of energy distribution risks (see broader overview in Silvast 2013).

Public electricity regulation: what does reliability cost?

Without large-scale energy storage, electricity has to be generated whenever demand occurs. If electricity demand exceeds supply or the distribution of electricity encounters a fault, the shortfall can be usually met by reserves or energy trading. These procedures increase costs to the providers, however, which then passes them on to consumer prices. Government policies, in turn, often focus on electricity prices, including restricting their changes or even capping consumer prices. This dynamic is important when considering what kind of a 'commodity' electricity is. Electricity does not have a 'pure' economic market, but the free trade of energy is allowed in a policy framework. Typically, these frameworks are enacted by energy market regulators – quasi-legislative bodies that monitor the operation of electricity utilities and assign various kinds of targets to them (Silvast 2017a, 2017b). Energy provisions are actively tamed by the regulations in terms of 'fairness.' These tamings, for their part, have impacts across the sites of the electricity infrastructure.

Many European countries' electricity regulation shared the same starting point until about 2000. Regulators started to tame the provisions by assigning price caps to the electricity network service charge that is billed to customers (CEER 2005, p. 31). Soon, however, the regulators noted that while taming one risk (overpricing), this mechanism created another. When prices are capped, electricity network companies might reduce their maintenance and investments to make a profit. According to an established framing by economists (see Gramlich 1994), a lack of investments in turn directly influences the quality of infrastructure provision: 'Price-cap regulation without any quality standards or incentive/penalty regimes for quality may provide unintended and misleading incentives to reduce quality levels' (CEER 2005, p. 31).

The next generation of electricity regulation models, which have become increasingly popular in Europe since around 2005, strive to monitor this electricity supply quality and motivate its improvements (CEER 2005, pp. 31–32). In practice, statistics on quality are made public; 'incentive' and 'penalty' schemes are enforced upon utilities to control their profits in terms of their quality of supply; and there is a growing number of arrangements that fix maximum limits for electricity interruptions – i.e. blackouts – and customer compensation for cases when the limits are exceeded. Along with compensation, however, a related matter has been making customers aware of the costs of quality. Thus, specific emphasis has been placed on electricity customers' 'expectations' and 'their willingness to pay' for good-quality electricity (CEER 2011, p. 4). As the organisation Council of European Energy Regulators summarised it: 'Results from cost-estimation studies on customer costs due to electricity interruptions are of key importance in order to be able to set proper incentives for continuity of supply' (CEER 2010, p. 9).

As can be seen, these market regulations are attempting to tame electricity infrastructure and its risks on multiple scales. Energy regulations provide ways of understanding how companies providing electricity should act – via having 'proper incentives' – in their everyday work. They also concern the rationalities of lay people and the ways they can be turned into rational agents that constantly estimate the costs of having a continuous power supply in their workplaces or homes. At the same time, these models do not encapsulate the concrete taming work for the diverse power infrastructure. As a senior manager in an electricity company remarked in the study, we know how energy quality regulation and its optimisation is supposed to work, but not so much about how regulation enforces specific maintenance arrangements and the preparedness arrangements that are in place especially to optimise the regulation model (Silvast 2017b).

Recent scholarship has drawn attention to this need for active maintenance work on infrastructures. Stability, continuity, and economic efficiency, in addition to preventing breakdowns and responding to disruptions, have to be maintained every hour of the day in provisions such as current infrastructures (Luque-Ayala and Marvin 2016, Anderson and Gordon 2017). Workers in specialised electricity control rooms (Roe and Schulman 2008, 2018, Silvast 2018) are responsible for this continuity and the quality of electricity distribution, as well as for purchasing and generating electricity to be distributed according to various local demands. The infrastructure being framed as coherent across sites depends on the connections that these control rooms make between electricity generation, power markets, distribution networks, and the households' energy uses. The control room then reveals significant parts of how the infrastructure is constantly tamed to function coherently and robustly.

Managing electricity supply, markets, and risk in two control rooms

This research site was situated in an electricity company in a Finnish city. Before the 1990s, a single electricity utility covered the entire supply chain to the city, ranging from energy generation in power plants to electricity distribution, customer sales and billing, and the maintenance of the electricity network. Following energy market liberalisation, a process that started in many Western countries in the 1990s (Graham and Marvin 2001) and now includes all EU Member States, the electricity infrastructure is no longer organised in this way. Electricity generation and electricity distribution are different functions in a liberalised infrastructure; these infrastructures have been 'unbundled' so that market competition is permitted in generation, but distribution remains a local monopoly. As a result, their ongoing control and management has also been divided into two units – i.e. two *control rooms*. One control room is responsible for managing and trading the generated electricity and matching it with demand in real time, and the other control room is responsible for maintaining the actual distribution of the electricity in a continuous and reliable manner to the consumers via the local electricity grid.

The two control rooms in the field study were both part of a company supplying electricity. The staff working in each room had clearly defined roles and functions. The patterns and rhythms of their work had differences, but also similarities (Silvast 2018). Following the terminology employed in the company, we use *electricity network room* to refer to the control room responsible for the electricity grid, and *energy market centre* to refer to the room in which people operated in various energy markets. The two control rooms were next to each other, separated only by a wall. According to the principle of unbundling, however, the operators were not supposed to 'know' about each other's activities. In practice, they could have easily talked to each other through an open door or in the kitchen that they shared. Both in terms of the formal organisation and the working habits, the two control rooms, their work, and the risks that they dealt with differed in terms of their temporality, rhythms, used metrics, and responses.

The duty of the *energy market centre* was to participate in the Nordic common energy market, Nord Pool, whose headquarters is in Oslo, Norway and which links energy market players in Finland, Sweden, Norway, Denmark, Estonia, Latvia, Lithuania, and parts of Germany. The pool, as the electricity industry in Finland characterised it, 'is a kind of a stock exchange that gathers daily the sale offers from electricity providers for each half an hour and determines the system's market price' (SENER 2000, p. 10). The seven brokers in the control room, who work in shifts throughout the day, were responsible for making these transactions happen for the city's energy supply. In practice, they balanced energy levels in two electricity markets. Firstly, they used the Elspot market to manage the supply and demand of the day ahead. A second energy market that has gained more importance over the years is called Elbas. Rather than concerning the day ahead like Elspot, Elbas is a real-time, hour-ahead marketplace that has operated in Finland and Sweden since 1999, Germany since 2006, Denmark since 2007, and Norway since 2009.

Elspot orders were placed on the energy stock exchange once per day, at 13:00 Finnish time (12:00 Norwegian time due to the time difference). One of the workers explained the day-ahead Elspot bid and offer process as follows:

> On the morning shift, we make the next day's prognosis, where the power plant's generation power is defined based on the weather situation, and from there the electricity needed. From there on, we also send the order to Norway (to the energy stock exchange), which has for each hour the information on the price at which we are willing to sell and buy (energy).

At 13:00 each day, the company then sends its 'order' – the price at which it is willing to sell and buy energy during each hour of the following day – to the Nord Pool stock exchange. However, much skill is required, and the necessity to place the order at a specific time was instituted by the energy markets. Another relevant temporality of the work was shaped by the real-time market, Elbas.

All the operators in our study emphasised the ever-changing contexts of day-to-day practice, and the real-time market certainly seemed to raise this intensity. Even when little is happening, the worker's main task is to stay alert. One of the workers summed up energy trading as watching a campfire: 'You have to be constantly maintaining a small flame. That is, you mustn't fall behind the energy stock exchanges.' Here, again, the expert work is framed vis-à-vis the energy market; actors manage electricity and its always-on, reliable provision in a specific compressed timeframe of the market.

However, when interviewed, the informants made it clear that their work is not merely about following markets on computer monitors and interacting with them according to hourly and daily rhythms. The work critically required special skills and capabilities. Both ordering energy for the day ahead and adjusting it hour-by-hour provided useful examples. The ordering, for its part, is shaped by the difficulties of predicting the weather, which directly affects energy usage in the combined power and district heating that the company provided. This requires active taming work, usually in the form of finding a 'comparison day' that had had a similar temperature and consumption pattern as the day ahead. For this, the same days of the week were preferred: weekdays tend to have a slightly different energy consumption than days on the weekend. However, only part of the process of ordering could be thoroughly reflected; as one of the experienced workers reported, he could draw on his 'gut feeling' to foresee the energy demand on any one day of the week:

> Tuesday, Wednesday, Thursday, they could be similar to each other in the middle of the week, then you have Friday, Saturday, Sunday, even Monday, they are little bit different. But that starts from your guts in a sense, that you somehow suspect that they have some small difference.

Hunches and intuitive moves seemed just as important for the real-time trading, which invoked images of what one of the workers termed 'managing a living infrastructure':

> The process is alive all the time. We try to keep up with the district heating network and act as a counterweight to it. It's alive all the time. When we make some guess about the temperature and what the consumption could be, it's a living process, even though there have been similar temperatures in the past. It's alive, and the production is alive too.

As for the *electricity network room*, the aspirations for unbundling – which had existed for years at the time of the study in 2008 – had already created highly specialised working tasks for the two control room workers. In practice, the technical control room work involved a number of main recurring tasks. First, the continuous monitoring of the voltage, current, and temperature of the components of the electricity network was carried out on several computer screens. Second, when new components – like lines, transformers, or power stations – were installed, the control room operators needed to redirect the power flow across the network. Third, the management of a repair team might be required when a component failed and triggered an alarm.

Even the third case was not a clear-cut non-routine event in terms of being a disruption of the prevailing framings to these workers. One operator had not counted how many alarms there had been in a single day, but an event list on a computer screen showed 36 pages of events for that particular day. Not all of these events set off an alarm, as some are 'invisibly' solved by automatic fail-safe devices. When an alarm occurs, the task is to first report the details of the fault to a computer software, then to determine whether a maintenance team is needed. If it is, a team must be sent into the field and the fieldwork must be coordinated in relation to the information on the control room computer screens.

The working rules and protocols considerably help the effective taming of these on-the-spot behaviours:

> Interviewer: Are there many rules that are followed even though situations change?
>
> Operator: Well, of course there are security and other sets of rules about what should be done. You have to act according to them. And every operator has to have the same point of view about those things. That doesn't change according to who sits here.

Thus, the working practice of the room follows strict sequences of actions when 'security' is considered. Cognitive styles of reasoning, embedded in rules and protocols, produce an everyday frame for the work tasks. Standardisation tries to produce one type of framing that does not depend on the worker nor demand continuous cognitive taming, but due to the complexity of the infrastructure, full standardisation is impossible. Active taming work is therefore also required.

With this considered, the informants emphasised how skills and in some cases even improvisations may be necessary as a purely practical matter:

> In principle, electricity work is usually highly standardised. If everyone follows the standard, then it is highly structured. There is the problem, however, that when you go to a work site, the situation might vary greatly. And then it comes down to how you want to do things.

The actual work site introduces uncertainty that requires special skills. Another broader source of uncertainty is given by the complexity of the managed infrastructures and the difficulty of finding which of the many possible processes led to the failure.

In summary, both control rooms' working arrangements ensure the consistency of the infrastructure as experienced by consumers, but they do it on different – although closely related – terms. Below, we outline the methodological concerns that this generates.

The MSAI and its conceptual toolkit offers a route for this analysis. Firstly, these two control rooms demonstrate that infrastructure is made up of different framings and tamings, as well as alterations between the two. In the electricity network room, experts continuously attempt to tame and frame the infrastructure by monitoring and controlling a number of the electricity grid's inputs and outputs, including the temperature of the components, the voltages along electricity lines, and the stability and safety of network parts. In the case of the energy market centre, the infrastructure is tamed and framed by bids and offers that represent the value of the generated energy in monetary terms and quantities to be sold or bought on the Nordic common power markets.

In addition to the diversity of infrastructure assemblages, the MSAI also steers observations towards the concrete overlaps of different framing and taming practices, as well as the translations between them. Although we have emphasised the different forms of network management and the types of expertise involved in each control room, it is important that the operators in both rooms tame electricity consumption despite doing so in very different ways (see Silvast 2018). The energy market centre deals with abstract and aggregate measures of demand – representing consumers whose needs and ability to pay are anticipated to generate the best possible energy market price. Those responsible for the network focus on households and end users facing specific and localised problems with the reliability of their electricity supply. In comparing these coexisting and related forms of taming the infrastructure, the MSAI produces new insights into the daily enactment of the electricity infrastructure and the market arrangements involved, particularly by showing how supply and demand are managed in practice across electricity distribution and markets.

This leads to a third point of concern, namely recognising actual asymmetries in framings and tamings. While markets and technical security offered a different frame for the infrastructure, they were not always simply alternatives to each other. At the time of the study in the two control rooms, the market-based management of risk assimilated the prevention of technological risks in a manner that seemed almost automatic. This was apparent on the free power markets, where risks are always tamed to fit the market frame, mostly as bids and offers. Earlier the market was simply framed as means of profit (Nord Pool 2010), but it is increasingly framed as aiming to reduce the financial impacts of unanticipated incidents, such as wind power intermittency, in real-time (Nord Pool Spot 2017).

The electricity distribution room involved the more formalised prevention of hazards, with significant assistance from work experience and localised framings. Even in this room, however, some degree of market competition and optimisation had been potentially *performed* (Silvast 2017a) via the economic tools that the operators had to use: the workers calculated the working costs of fixing the electricity grid, determined whose financial and legal responsibility the fault was, and contracted outsourced maintenance teams. That said, the infrastructure was still mainly tamed from the point of view of maintaining safety rather than economic optimisations.

These framings and tamings and their balances are not permanently fixed, even if from the end user's point of view, centralised infrastructures of electricity and heat often appear to be static. Control rooms were chosen as the object of study because they contain rich and diverse performance modes and skills, as ethnographic research has shown (e.g. Roe and Schulman 2008, 2018, Suchman 2011). Nevertheless, it would be very difficult to understand how control rooms work without explaining what exactly they are trying to control: the 'inputs' of control rooms are electricity and finances, and their 'output' needs to match the everyday needs of regular people and all the end users. In fact, as was revealed, the control room work continuously reflected the consumers, whether it was by anticipating energy needs of the day ahead, fixing those predictions more or less in real time, or adjusting the faults that the householders experienced in their homes. On the one hand, framings and tamings diverge between control rooms and households as electricity is not on the foreground in households but framed as a valuable background resource for everyday life instead. On the other hand, this background framing was also present in the control room as the workers tamed electricity by trying to procure adequate quantities and continuous supplies, using predictive and reactive maintenance, and engaging actively in market trading. While doing this, they also had to make estimates and assumptions about energy-using householders.

Infrastructure risk at home

In scientific and regulatory studies on power infrastructure and reliability, experts typically assume that lay people are constantly thinking about their willingness to accept risk or the willingness to pay for security of supply (CEER 2005, 2010, 2011). However, these studies have also discovered that often, householders are uninterested, unable, or even unwilling to do such calculations in everyday life (see Kivikko *et al.* 2008). Corresponding issues were visible in the control room work. The utility fault phone line, where energy customers could contact the control room, was often called by users who the workers considered ill-prepared for the almost inevitable potentiality of their power occasionally failing. This potential mismatch between how scientists and experts assess risks and how consumers understand them has been summarised as the deficit model of public understanding: namely, a model of a public that lacks the necessary knowledge of technology and is therefore typically critical of technological developments and risks (Ryghaug *et al.* 2018).

The research aim on this field site was to expand the premise in a qualitatively rich direction. The study wanted to understand how ordinary people – individuals in households – act and think about electricity supply disruptions, from short power failures to prolonged shortages, in their everyday lives. This is an area of growing research interest in STS and the social research of energy (e.g. Trentmann 2009, Rinkinen 2013, Heidenstrøm and Kvarnlöf 2017). Earlier studies have shown that people and households are not merely vulnerable to interrupting electricity infrastructure; rather, everyday preparedness and skills can mitigate the risks triggered by the electricity supply failing, and indeed, the failures uncover normally hidden household skills and resources.

Nevertheless, nearly all of the informants in the study – whether they appeared to be prepared or not – seemed relatively relaxed about power shortages. They were also explicit that not all such disruptions are especially harmful. Power failure and its possibility was framed as ordinary, a minimal disruption of everyday habits. For example, one interviewee, a retired woman, mentioned the wood stove that heats her old house and emphasised that she would have ‘no worries’ during a blackout:

> Personally, I have no worries; there is a wood stove here as this is such an old house. But then the neighbour’s house doesn’t have wood heating, so they started to complain [during a long blackout] that it was getting a bit chilly.

A blackout did not represent a crisis for the interviewee, as its occurrence demanded no active and cognitive taming work. Rather, she managed to continue key everyday habits – at least those requiring heating – even though the electricity supply was interrupted. She knew from repeated experience that the wood stove would keep the house reasonably warm. Indeed, almost all interviewees explicitly stated that not all blackouts were harmful events. One interviewee said that blackouts have not caused her any harm personally, while another might even accept one further blackout a year. The respondents of the survey expressed similar thoughts; they thought they could cope for many days without using electrical appliances.

At first, the study seemed to support the view that people are generally unconcerned about energy supply risks. Many people simply accepted that electricity blackouts can happen, especially when they were framed as being triggered by acts of nature. They downplayed the effects of these ‘inevitable’ blackouts and did not think it necessary to respond to the events or anticipate their onset.

The deeper the analysis went, however, the more apparent it became that what was at stake was not just a simple fatalistic framing of risk. Rather, there were various kinds of power failures, and these different kinds of interruption were framed in a different manner in various situations. The acceptance of blackouts varied according to gender, age, region, and especially memories of previous blackouts. To be acceptable, a blackout also had to be ‘voluntary’ rather than imposed from above.

Such an acceptable electricity supply interruption, it was anticipated, should not halt those household practices that were perceived as important, and also it should not prevent less significant practices regularly or all the time.

For example, as one respondent remarked, she would not want to have a blackout when needing to submit her thesis or, more mundanely, to go to a party or watch a television series. One interviewee had even more persistent problems with electricity blackouts. Practically all the woman's appliances were electric, from her regular household appliances to her air conditioning, water fountains, and, unusually for 2005, even her car.

Infrequent power interruptions may be acceptable and even have positive aspects, but as frequent occurrences, blackouts can become both unbearable and untameable:

> For us, a blackout is not just an interruption. Instead, it is a difficult-to-cope-with situation where every morning the phones may start ringing at five in the morning so that the whole family wakes up. Because this is a new house, everything is automated. And if there's a blackout and for some reason a programme is erased, then certainly it's a nuisance that you have to spend an hour entering the data again. For a person who doesn't have this equipment it's just a matter of resetting the digital clock. But we live in a house where everything runs on electricity, and modern technology is complex.

Some blackouts were hence framed as more serious than others were. Confronted with difficult actual harms, another, almost opposite risk response to fatalism emerged: many people wanted to prepare for interruptions using, for example, wood stoves and fireplaces.

It was viewed by some that reasonable people should know how to cope with blackout situations – an ex post frame that helped to tame the impacts of power failures by recounting how the subject could have acted in one. People also wanted to ensure that a blackout would not disturb the everyday routine too much and criticised utilities for downsizing their maintenance and other risk management capabilities.

The MSAI lets us outline the distinct framings and tamings in which households construct infrastructures when regarding failure and risks. The electricity infrastructure is framed, first of all, by its embeddedness in the materiality of the household as it is utilised by household technologies like lighting, cooking, media, and computing; by everyday habits; and by clusters of practice (Silvast and Virtanen 2014). The use of electricity and the reduction of the complexity of a failure is largely a matter of practical framing. It involves issues like skills, installed electric equipment, situated preparedness, and explanations – including blame and scapegoating (Douglas and Wildavsky 1983) – that hide the electricity infrastructure rather than open up its functioning to active taming.

If electricity infrastructure is framed in households as a blackbox, what then happens with the second scope of the MSAI – concrete overlaps, connections, and translations of different framing and taming practices? Clearly, household energy use practices cannot be fully understood without analysing the rich and situated associated meanings, competences, and routines, which as such, place infrastructures in a background role (Shove 2017). The MSAI joins and complements this focus by stating that different framings and tamings not only background but also foreground the infrastructure and overlap in many ways that can be scrutinised further.

For one matter, the market frame of the energy infrastructure overlaps with everyday energy use practices, whether people think about it actively or not. For example, if customers are assumed to be active, they are assumed to be cost-conscious also in terms of reliability and the continuity of supply costs, as noted above. Patterns of electricity consumption are moreover affected by various more durable institutions and arrangements: billing practices, legislation, and even the physical geography of the electricity infrastructure. All these issues are furthermore linked to the active taming work of risk by the energy companies.

In Finland, a persistent difference in the reliability of electricity networks exists in the countryside and urban areas: the reliability in urban areas is higher than in rural areas, and the countryside continues to experience especially difficult years with long power failures (Energiateollisuus 2019). Over the past decades, the difference in electricity supply reliability was shaped by whether an energy user's household is in what the energy companies and energy market regulators framed as rural or urban, which depended on the ratio between underground and overground cables in the area. This taming and framing by infrastructure providers and regulators can have a tangible impact on the kinds of equipment that the households can use on an everyday basis considering the expected frequency of power failures.

The third scope of the MSAI, the question of actual asymmetries in framings and tamings on different sites, has direct relevance to further addressing these issues. If decisions on moving to the countryside have to meet one's 'willingness to accept' power cuts or the 'willingness to pay' for a personal emergency generator, this presupposes individuals that can reflect on financial harms and compensations. Thus, those with calculating capabilities and relevant resources and tools may gain better-quality infrastructures. As two scholars in the social study of markets note:

> The most powerful agencies are able to impose their valuations on others and consequently to impact strongly on the distribution of value … [I]t is by affirming the autonomy of calculating agencies that markets are able to conceal and to legitimately impose the asymmetries that develop out of the achievement of calculative capacities. (Çalışkan and Callon 2010, p. 13)

Economically rational tamings of the energy infrastructure shape – and function through – economically rational consumers. However, the mundane framings by these consumers-in-the-making do not always fit this rational frame without friction (Virtanen 2019).

Discussion and conclusion

Methodologically, the key argument for doing in-depth single-sited studies has been the attainment of more depth, rigour, and systemicity (Gobo 2008). This approach promises the thick description that is the specialty of the traditional anthropological field method, and it is still both common and valued in STS following its 'localist turn' (Pollock *et al.* 2016, Hyysalo *et al.* 2018). Multi-sited ethnography has been challenged on the count that it 'spreads the ethnographer too thinly across the space' (Candea 2013, p. 252). Against this critique, we would argue that multi-sited methods such as the MSAI are not merely aiming to add research sites across space and time to a case study. Rather, they provide a new language for ethnographic inquiry that combines (i) specific concerns on different sites, (ii) the implication of these concerns on the larger scale, and (iii) the examination of how the different sites and the different framings and tamings found there relate to one another.

This inquiry can be guided by what anthropologist Stephen J. Collier (2011, p. 29) describes in his own multi-sited fieldwork of infrastructure in Russia: 'specificity of a certain place, … oriented by the weight of its problems, by the density and polyvalence of the experiences that one finds in it, and that leads to other sites, where other techniques of inquiry must be used.' With the understanding that scholars have developed of single sites of energy infrastructure, it is apt to start considering techniques of inquiry that go beyond and link these sites. This would allow the following of constant enactment of infrastructure as a multi-sited socio-technical assemblage on different scales.

Infrastructure studies have long been aware of the double character of infrastructural systems: infrastructures remain invisible at large, but this is made possible by myriad of locally visible arrangements and procedures. The method of *infrastructural inversion* (Bowker and Star 1999, Karasti *et al.* 2016, Parmiggiani and Monteiro 2016) has been developed to expose and study this inner life. This means examining those technologies and arrangements, maintenance practices, physical networks, standards, and political and ethical consequences that are normally hidden from everyday life. The MSAI and its concepts of framing and taming are directly compatible with this classic approach. They attend to the infrastructure itself, its contexts, and the concrete work that makes the infrastructure come to life on sites such as public regulation, energy companies, and ordinary households.

Yet, we also complement and advance this approach conceptually by distinguishing between mundane framings and technical tamings, both of which ensure the consistent functioning of infrastructures across different sites. For instance, market regulations, electricity control rooms, and households are part of the same material electricity infrastructure, but it would be very difficult to appreciate their diversity without 'inverting' the infrastructure and framings and tamings of all of them. The economic taming procedures used by the regulators, the day-to-day taming work in utilities, and the social, mainly unreflected framings in households have the potential for friction because of their differences, in terms of both technical reasoning and day-to-day meanings.

Our method's attention on interrelations between different infrastructural sites relates to another classic approach in infrastructure studies, namely *boundary objects* (Star and Griesemer 1989). By definition, boundary objects are artefacts, concepts, or methods that lie at the interface of different social worlds, such as politics and the economy. Because their identity is understood across these worlds, they enable co-operation and coordination between them. For example, the concept and calculation of infrastructure risk has certain resemblance to such boundary objects. When regulators tame the reliability expectations of consumers by 'their willingness to pay' for good-quality electricity, when control rooms tame daily energy demands while complying with the regulatory model, and when householders refuse to open their routine framings and tame energy risks anew, all of these interactions and interdependencies change the ways in which the infrastructure can be managed and governed. In a general sense, infrastructure risk could therefore be understood as an 'object' that these different social worlds share.

But MSAI also differs from this important underpinning in STS and infrastructure studies. Rather than objects which mediate and also reveal the dynamics of different social worlds, our research design starts from the analysis of multiple field sites where framings and tamings of infrastructure become visible. At its simplest, the MSAI adds more sites to one study in the literal geographical sense. For the empirical case of this article, energy-using households in Finland are clearly in a different space than the control rooms of an urban utility, the public regulatory models, and the Nordic power market with its further connections to European-wide markets. However, this kind of expansion of sites is not the key aim of our methodology. The MSAI goes further than only proliferating field sites. Rather, our research design places attention on the differences and similarities, frictions, and continuities among research sites, such as the sites of an electricity infrastructure.

Our attempt to go further than ethnographic snapshot studies also has several parallels to the recent research programme of methodology in STS, the Biography of Artifacts and Practices (BOAP) (Pollock and Williams 2009, 2010, Hyysalo *et al.* 2018). Like these advancements, MSAI builds on research designs that are multi-sited and aim at addressing multiple interlinked settings of technologies. However, we would like to stress two important differences to BOAP. Firstly, the BOAP has developed an essential interest in the longitudinal study of changing technologies, but the MSAI addresses different adjacent and interrelated sites over the same period of time and puts these within a historical context. Secondly, the MSAI does not merely follow artifacts and technological actors – such as designers and users of consumer products and services (cf. Rommetveit *et al.* 2017, Silvast *et al.* 2018) – but guides fieldworkers to examine different socio-material worlds, which are termed as sites of the infrastructure.

Reflexive discussions on the rigour of research methodologies have become growingly common in STS and energy social research in recent years. This article participates in these debates and contributes to research design in infrastructures and energy studies in particular. Together, energy infrastructures and multi-sited ethnography create a vital yet unexplored research field where further discussions of the relevant methodological tools and what aspects of infrastructures they identify are highly needed.

Notes

1. The sequential alternations of framings and tamings resemble the doubt-belief cycle of action processes highlighted by classic pragmatism (Kilpinen 2010): a disruption of a state of belief, as the unreflected phase of action, leads to a state of doubt and the ensuing need for reflection, which, for its part, starts to stabilise as a state of belief again.
2. The control room informants were found through the first author's fieldwork in the Finnish electricity sector, particularly through contact with the managers of the workers. The questions posed in the control room

interviews concerned the anticipation of electricity supply failures and the management of their damage as risks. The questions were divided into sub-themes about working practices, energy markets, and security in the control rooms. The control room operators worked for one electricity company in Finland and were males in their fifties or sixties, with the exception of one younger female worker.

3. The questions for the households concerned electricity supply risks in the home. The household interviewees were found through various means, including through a housing association and 'snowballing' new respondents from those subjects that had already replied. Both female (7) and male (2) respondents from the greater Helsinki region were included in the household interviews. The household survey (115 respondents, response rate 21%) was posted to the customers of two electricity companies in Finland, one for a city and the other for a rural region. The structure of the survey included four sections: the household impacts of electricity supply interruptions, preparedness against them, lessons from them, and attitudes. The survey responses covered all adult age groups, and both men and women were represented – however, the majority was male, more than half were over 60, and most lived in an electrically heated detached house.

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